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INTRODUCTION

The station in 1943 continued in large measure the war-time program adopted in 1942. With reduced personnel and funds, the bulk of the station's resources were devoted to the analysis and publication of accumulated research data and to assistance in Departmental planning of direct usefulness in the field for increasing the production of food and fiber and for protecting the wildland resources from irreparable damage. An irreducible minimum of effort was devoted to the maintenance of long-time records for the purpose of preventing irrecoverable losses of past investments in time and money.

The station published many useful papers. The store of accumulated basic data is by no means exhausted, however, and many more contributions will be forthcoming in 1944.

Flood control survey activity was terminated in midyear. The survey effort has stimulated much interest within the region in the functional activity of watershed management, resulting in many requests for technical guidance in this field from the station.

Post-war planning activity became increasingly heavy toward the end of 1943, with indications that planning efforts may be even greater in 1944. The major contribution in this connection so far has been in conjunction with Department programs. Investigations to date have opened new and important fields for intensified research in the post-war period. Immediate consideration should be given to the development of detailed plans for conducting these studies well in advance of the post-war emergency period.

Statements of division accomplishments and plans follow.

RANGE-WATERSHED CONDITION STUDIES

A field study undertaken by Ellison and Croft aimed broadly at evaluating the indicators and criteria commonly used in judging range condition and trend, and if possible to find new indicators, was discussed at some length in the 1942 report. This study was undertaken because of an apparent "inability to interpret correctly the effects of past and present use on vegetation and soil, or to perceive the rate and trend of change." That this is still a number one problem has been attested numerous times in the past few years by the great diversity of opinion, amounting at times to completely opposite views, between range

men as to both condition and trend of specific ranges. Such wide divergence of opinion concerning the extent of range deterioration seems to indicate that there are distinct gaps in our knowledge concerning both range condition and range trend. The study was aimed primarily at finding these blind spots in our knowledge and to supply the facts necessary to fill them.

The report of this study, "Principles and Indicators for Judging High Range-Watersheds" has been completed by the authors and is now ready to be reproduced in preliminary form for field use. The report contributes toward improved range management in two major ways.

First the report shows the kind of procedure in range inspection necessary to ascertain significant facts and from these to draw sound conclusions. To this end the following four major features of the report contribute most:

1. Presentation of the ecological principles essential to an understanding of the meaning of the indicators of range condition and trend. While these principles are well known to ecologists, a great lack has existed in that heretofore they have not been available to range managers in a form applicable to the management job.

2. Clarification of objectives in management. The primary objective, of universal application, is defined as a range of which the component parts--topography, soil, climate, and biota--are in balance. The secondary objective, which varies from place to place, is a vegetal cover of some desired species composition. The emphasis in this is fundamentally different from that of the traditional approach in which emphasis has been primarily upon species composition, and the essential, normal condition of balance, if recognized at all, has been made almost incidental.

3. Description and evaluation of indicators of range condition and trend in relation to the above management objectives.

4. Description of the necessary steps and reasoning processes during a range inspection to reach a conclusion as to the condition of the range and the changes currently taking place on it.

Second, the report clearly indicates by demonstrating the complexity of the range and the special skill and knowledge necessary to arrive at sound conclusions, that highly trained technical personnel are needed if range condition and trend are to be reliably ascertained. The range manager at present is so greatly burdened with duties that distract his efforts from the technical range job that he cannot give it the unremitting attention it deserves. Yet, unless he constantly studies the range with expert understanding, he cannot learn the facts he needs to guide his management. Clearly technicians are required who are especially trained for, and who can give their entire effort to, determining the facts relating to the condition and trend, as advisors to the range manager. This need has its analogue elsewhere in Forest Service organization: if a construction job requiring

specialized engineering skill is being undertaken, the ranger and supervisor are not expected to carry it through by themselves. On the contrary, specially trained engineers are assigned to the technical parts of the job. The same principle applies in range management, but with this important difference: whereas most of the facts used by engineers have already been assembled and tested, with well defined rules of application, the facts on which range management depends must as yet be worked out separately for each range. No central expert can make a quick survey of some range unfamiliar to him and deliver the answers. Too little of range ecology is known for this as yet, and ranges are too varied. The technician must study the range, and to study it he must live on it. This means that technicians must be assigned as staff advisors to separate range management units. Such, at least, is the conclusion to which one is led in considering the problem of getting a sound, factual basis for determining range condition and trend.

Plans for the Coming Year

The report will be reproduced in suitable form for distribution in Region 4 by the time the field season opens. Ellison and Croft will spend considerable time in the field this summer in testing and checking all phases of it against observations on very different range from those on which it is based. In addition they will work in the field with rangers and others, and by putting the report into practice in judging condition and trend, search out its weak points and deficiencies, after which it will probably be presented for formal publication.

RANGE RESEARCH

UTILIZATION STANDARDS

Study of utilization standards is an outgrowth of increasing awareness by forest officials of widespread range deterioration. Unsatisfactory range conditions have developed as a result of grazing over extensive areas, the full import of which was not recognized.

Deterioration in plant cover and soil mantle on many areas has continued under management. This demonstrated to range managers the need for standards whereby condition on range lands could be ascertained and limits of maximum use determined. In an effort to find a solution to this problem, research studies were initiated at this station in 1937.

From the first it was evident that the over-all problem comprised several phases. One of the first requisites to establishing utilization standards is some means for reliably determining the degree of current utilization of forage species. A second phase involves ascertaining the maximum use that range forage plants can withstand and still maintain their vigor. Greatest permissible use varies with season of use, character of growing season, soil type, soil condition, slope, exposure, associated plant species, and biota. A third phase deals with the manner in which plant

vigor is affected by treatment, site, environmental influences, and seasonal growing conditions. A fourth consists of determining what constitutes reliable indicators and criteria for judging range use and condition.

The problem of establishing standards of utilization for the vast number of range types in the Intermountain region is far from a final solution although definite progress has been made. Methods for estimating the degree of forage utilization have been developed and adapted to range use. The feasibility of using key species and key areas as guides to management has been more fully appraised, and specific information on plant vigor as influenced by grazing treatment and site is accumulating.

Ocular-estimate methods, in which accuracy of estimate readily can be checked by actual weight determinations, have been found practical for range use. Ocular-estimate methods have proved sufficiently rapid, accurate, and adaptable for many classes of forage under widely variable growth conditions. It was shown by trial that technicians trained in ocular-estimate methods can estimate percentage utilization rather consistently within limits of approximately $\pm$ 5 percent, providing a goodly number of observations are made. Small plots of 5 to 10 square feet in area have proved efficient sampling units, thus permitting larger numbers of observations than can be obtained with usual 100-square-foot plots. Field trial has demonstrated that a trained estimator can cover the average ranger district in approximately two days of field work, another one or two days being required to compile and tabulate the field data.

The concept of key species and key areas as commonly used has been found somewhat inadequate for judging current use and range trends. A given species is likely to be used much more heavily when it comprises a small proportion of the plant cover than when it comprises a large proportion. Since a species is not utilized to the same intensity under various conditions, a single species is not a satisfactory "key" indicator.

Many range managers are convinced that a successional stage not far below the pristine plant cover should be the goal of range management. One needs to be able to interpret what is happening to the rich admixture of species usually found in this pristine cover. This cannot be done if observation is limited to one or two major forage species on a site and to two to four on a range allotment. Ordinarily, five to eight will prove safer and highly variable areas may require an even greater number.

It has been found that plants have less vigor and decline in vigor more rapidly under close grazing on poor sites than on good ones. Mortality is also higher under adverse treatment on poor sites. Available data do not adequately separate the influence of the two variables--treatment and site. The combined effects, however, should not be overlooked. In one case, for example, individual plants growing on a moderately favorable site produced 64 percent more forage the year after being subjected to 50 percent utilization than plants on a similar but more abused site which was utilized to about 70 percent. On an acre basis, forage yields were three times greater on the better site.

At another location mortality in established slender wheatgrass plants on a favorable site and grazed to about 55 percent amounted to 6 percent over a 2-year period, in contrast with a mortality of 66 percent on plants grazed to 70 percent on a somewhat more deteriorated area.

A number of studies have been completed and findings are now being brought to publication. One paper on species variability in forage production has been submitted to the Washington office, and one regarding spring grazing on wild-hay meadows will soon appear in the Journal of Agronomy. A report, "Test of a Modified Ocular-Estimate-by-Plot Method for Determining Percentage Utilization" has been submitted to the Supervisor, Manti National Forest, Range Management Region 4, and the Washington office. Preparing four other papers will constitute the major job for 1944, as follows: (1) seasonal changes in chemical composition of major forage species; (2) variability in plant measurements; (3) influence of grazing on plant vigor; and (4) influence of degree of utilization on productivity of aspen and oakbrush ranges.

Field studies in progress which will permit a fuller appraisal of the effects of site and treatment are to be maintained on a minimum scale. When expansion of personnel permits, investigations dealing with the physiological response of plants as affected by season and intensity of use under different environmental conditions should be undertaken. It is only by close investigation in these various fields that the effects of the separate yet intimately related variables can be isolated and evaluated, thus permitting meaningful utilization standards to be set forth.

SUMMER RANGE

Successful management of summer range for maximum forage production with stabilized soil and streamflow, is largely dependent upon facts discovered and principles deduced through summer-range research. To this end, the objective of summer-range research is to develop an understanding of the range and how it functions, especially in relation to the influence of grazing. An understanding of the range must be based not only on a knowledge of the components of the range complex--biotic, climatic, edaphic, and topographic--and of the relationships of the individual components to others, but on a comprehensive knowledge of their functioning as a unit whole--"the range." With the character of summer range varying enormously from place to place, the field of inquiry is practically limitless; but inasmuch as the effort must be limited and incomplete in some respects it is well to pause and consider the effectiveness of the attack in relation to the objective, and, out of innumerable directions it might take, how the attack may most effectively proceed.

The first important result of summer-range research at this station was the publication in 1919 of Bulletin 791, "Plant Succession in Relation to Range Management." In this pioneer study some of the major plant communities of subalpine range were investigated and broad relationships between them were outlined. The results reported have had widespread application in management.

Subsequent research has been of a more intensive character. This more intensive research has included studies of erosion-plant cover relationships, studies of the seasonal development of vegetation as influenced by climate, studies of climate in relation to elevation on mountain range, studies of the productivity and carbohydrate economy of forage plants, and (shortly to be ready for publication) studies of the influence of microenvironment in natural revegetation. These intensive studies have contributed materially to our understanding of the range, and have been, and will continue to be, of help in varied ways in improving management.

With the background of achievement summarily sketched out, the question is, what now? What one of a score of possible lines of inquiry should be followed? Wherein is the working knowledge of range management least complete? What is the most important need at the present time?

We have carried these questions into the field in close association with rangers and supervisors and in observations of management practices on the range. Our observations lead irresistibly to the conclusion that the most serious lack at present is reliable means of judging range condition and trend. The range-watershed condition study, reported elsewhere, has endeavored to supply this lack, utilizing information now available. But additional knowledge is badly needed, particularly of the successional relationships of communities and the character of their vegetal composition in relation to their potential composition, as influenced by grazing. With this knowledge managers will be in a position to judge more realistically than they now can the significance of the existing vegetation on their ranges.

This is to say, the greatest immediate good can be accomplished through modifying and extending the work that was begun in Bulletin 791. From our plot records and observations, many facts have been discovered which will modify current concepts of the successional process; furthermore, the successions on other than subalpine ranges need to be worked out, for at the present time much of the most critical summer range is on the lower mountain slopes. In view of the great variety in summer range, the work must necessarily be extensive rather than intensive, avoiding specialized in favor of a comprehensive approach toward broad facts and principles which can be directly applied in management.

Besides cooperating in completion of the range-watershed condition study during the coming year, therefore, the summer range project will begin the task of an ecological range-condition appraisal of the Wasatch Plateau. Even though very extensive, in the nature of a survey, the study will require more than one field season--probably two or three, depending on the help that can be obtained. To supplement and help interpret the extensive data, numerous intensive plot studies and old photographs are available, plus two range surveys, a geological survey of the eastern part of the Plateau, and a considerable number of forest maps. It is hoped that, incidentally to the main purpose of working out broad ecological principles, technics will be developed in the field work, with which brief but informative ecological-condition surveys of other forest range can some day be made, with direct benefits to management.

SPRING-FALL RANGE

Methods of grazing management and intensities of stocking that would permit the fullest use of spring-fall ranges, and at the same time, yield the greatest possible production of forage, meat, hides, and wool were the major problems facing the spring-fall range project upon its initiation in 1923. Principles of spring-fall grazing management embodied in USDA Technical Bulletin 600 provided a firm basis for a renewed and more refined attack beginning in 1932 on the grazing capacity and most effective systems of grazing management.

At about this time sagebrush burning was recognized as an acute problem. Much promiscuous burning was being done by stockmen to rid their range lands of dense stands of sagebrush. Detailed studies were begun to determine whether the practice was good, or bad; and if good, how fire should be used to assure effectiveness and guard against injury. Definite progress has been made on both major problems--grazing management and sagebrush burning. Worthwhile principles of grazing management have been included in an initial draft of a manuscript on grazing spring-fall sheep ranges in Idaho. With the preparation and publication of Farmers' Bulletin 1948, "Sagebrush Burning--Good and Bad" simple direct rules on where, when, and how to burn sagebrush are provided.

Much remains to be done in the solution of grazing management problems of the spring-fall range. Relative merits of rotation and continual grazing systems need to be evaluated. Further study is needed to eliminate present uncertainty concerning grazing capacity of spring-fall ranges. Grazing management with cattle needs study. For the present, however, it appears that worthwhile findings are in advance of what it is possible to apply. Other major problems that are badly in need of solution stand in the way of application of known principles of good grazing management, or decrease the benefits from them.

Cheatgrass has long been recognized as a major problem. Its highly variable and extremely inflammable forage provides an unreliable base for sustained livestock production. Replacement by perennial grasses seems a possible solution. But without reduction in stocking there appears little possibility of restoration of perennials either through better grazing management or reseeding. New forage resources are needed on which to graze stock shifted from cheatgrass ranges.

Lack of adequate watering facilities and difficulty in constructing good storage reservoirs have prevented the application of rotation or other good systems of grazing management on much of the spring-fall range.

By far the foremost problem facing stockmen and range administrators alike is the vast acreages covered by dense stands of sagebrush, which introduce serious difficulties in handling range livestock, increase wool and lamb losses, and drastically decrease grazing capacity. Dense sagebrush is a problem on fully one-half the spring-fall ranges in the Intermountain Region. Vast areas, because of low grazing capacity and difficulties in handling

range sheep, have become totally unusable for sheep and are of low value for cattle. In a large sense, these are idle range lands.

Even application of the best known principles of grazing management makes but slight headway in increasing grazing capacity or decreasing difficulties in handling livestock on these dense sagebrush areas. Maintenance of present forage production and a very slow rate of increase are possible; but dense sagebrush is a barrier to rapid improvement through grazing management, or through reseeding. Eradication of sagebrush is therefore needed to hasten the process.

Sagebrush eradication offers great rewards. Not only are wool and lamb losses decreased, and difficulties in handling livestock lessened, but deteriorated range lands may in favorable circumstances be restored in 4 or 5 years to near their potential grazing capacities of from one-fifth to one animal-unit month per acre. By permitting part of the grazing load now carried on cheatgrass ranges to be diverted to such newly developed feed resources, sagebrush eradication also offers a chance to be of constructive help in improving cheatgrass ranges.

Burning provides a partial solution to the sagebrush eradication problem. Many ranges occupied almost exclusively by sagebrush, however, will not burn. On many more ranges burning should not be carried on--ranges with steep slopes, readily erosible soils, or on which water yields or timber crops are more important than forage yield.

It is necessary, therefore, to find other methods of sagebrush eradication for considerable areas. Relatively little is known regarding the mechanical removal of sagebrush or reseeding in conjunction with eradication. Intensive study of equipment, season of eradication, and widespread large-scale trials are necessary if low-cost effective methods of sagebrush eradication other than burning, and reseeding are to be developed for use by the range sheepman, cattleman, or administrator. It is felt that in the study of eradication methods the spring-fall range project can be of most immediate service. Accordingly, when personnel reductions and a demand for projects more closely tied to war food production were made, the major effort was swung from grazing management and grazing capacity studies to an attack on sagebrush eradication. Normal field work of the spring-fall project was sharply curtailed for the duration of the war, and herded-range grazing studies were suspended. Pastures used in grazing-capacity and system-of-grazing studies are being grazed according to plan but no detailed field data are being collected. Only minimum records regarding climate and plant growth are being maintained.

Almost all of the last half of 1943 was devoted to intensification of effort on sagebrush eradication. Available information was assembled on methods of sagebrush eradication and methods of reseeding in conjunction with eradication. In cooperation with the Grazing Service, large-scale demonstrations of sagebrush eradication and reseeding were set out in Idaho and Nevada. During 1944, and until substantial progress is made in

the solution of the sagebrush eradication problem, major effort will be devoted to the study of equipment, seasons of eradication, and establishment of large-scale trials of sagebrush eradication and reseeding.

During 1944 the bulletin on grazing management of spring-fall sheep ranges of southern Idaho, and a preliminary report on methods of sagebrush eradication are to be completed. The latter, based on the limited amount of information now available, is to be prepared jointly with staff members of the Artificial Revegetation Project and issued in mimeographed form for use by action agencies or interested stockmen. A problem analysis on cheatgrass is to be prepared jointly with Hull, and collection of a minimum amount of data on climate and plant growth studies at the U. S. Sheep Experiment Station continued.

For the less immediate future, attention should continue to be focused on the problems of water development and grazing management of sagebrush-grass and cheatgrass ranges for both cattle and sheep.

WINTER RANGE

Winter ranges in the Intermountain Region consist of approximately 65,000,000 acres of land receiving for the most part between 5 and 10 inches of precipitation annually. The scant moisture supply produces at best only sparse vegetation. The uncontrolled grazing to which this sparse vegetation has been subjected until a few years ago has greatly reduced the vigor of the best forages, and killed many of the plants.

The plant cover is much thinned on large areas, exposing the soil to wind and water erosion. On other large areas Russianthistle and other low-value species have occupied the spaces thus made, thereby protecting the soil and furnishing considerable but inferior forage. It was estimated in 1935 by those best acquainted with winter ranges that the forage production was only 50 to 60 percent of the potential. Moreover, the production of annual forage species was so unreliable in drought years as to reduce forage production to less than 30 or 40 percent of normal, exposing sheep to starvation and heavy death losses.

The Desert Station Experimental Range in Millard County, Utah, was set aside in 1933 and fenced during the next two years to provide facilities for investigating some of the more important problems of winter range, such as too high intensity and wrong season of use, trailing long distances to watering places or to snow, low forage and livestock production, and better grazing and herd management. The long, exhausting fall and spring migrations to and from the winter range, how best to handle supplemental feeds, and destroying the range around public shearing corrals are serious problems that require study and regarding which only beginning observations have so far been made. Investigations were begun during 1935 and during the next two years regarding the effects on vegetation and sheep of light, moderate, and heavy utilization of forage in late fall, winter, and early spring; regarding changes in vegetation both as to vigor and replacement of species; and regarding management practices in handling sheep.

Since 1937 when the investigations were fully under way, several important steps have been made in measuring the effect of managed grazing as compared with unmanaged. Under proper grazing use plant production by the best forage species increased by 50 to 200 percent and forage yield on an acre basis by a somewhat higher percentage. Good species such as Indian ricegrass, winterfat, and black sage when grazed under the best known management procedures, crowded out Russianthistle and reduced the production of desert rabbitbrush which is a low-value perennial shrub that had multiplied on overgrazed winterfat and ricegrass areas. Sheep responded to good management in increased wool yields of 1 pound per head, 5 percent greater lamb crops, 8 pounds greater body weight, 6 percent smaller death losses, reduced handling difficulties, and decreased costs. As a result profits for operators were increased by $1.00 to $1.50 per head.

Because many of these practical solutions are immediately useful, they have been prepared in a manuscript for a proposed bulletin which is now being reviewed by the Washington Office. Another manuscript treating the problem of hauling water to sheep is partly prepared, and compilation of data that bear on ecological principles and explanations is under way. The development of principles which will form a basis for application of the management procedures is not nearly as far along as are the practical phases already mentioned. Neither are the findings of such problems as seasonal effects of grazing so clear or conclusive as are needed. Investigations dealing with rotation grazing and repeated grazing at various periods during the winter still require much in the way of observation and data.

During 1944 the principal efforts will be (1) the continuance of the going experiments at minimum level so as not to lose the value of sequence in past work; (2) completing to publication the bulletin on management of sheep on winter ranges; (3) completing the manuscript on water hauling; and (4) compilation of data and preparing a manuscript treating certain ecological principles involved in management practice. When more personnel and funds become available, ecological studies need to be greatly enlarged and carried far enough to yield data adequate for developing much more fully than present findings now make possible, the basic facts and principles underlying practical solutions. When this is accomplished the practical procedures that have been more or less empirically arrived at and many others yet to be found can be carried forward with enough assurance to permit their being strongly recommended.

Also much in need of investigation are (1) chemical analysis, (2) storage of food reserves, (3) preference ratings, and (4) digestibility of major species of winter forage. Values of the various supplemental feed materials, water requirements of sheep and cattle, annual sheep migrations, and forage surveys at selected sites are all in need of study and would make important contributions toward better management of winter ranges. None of these investigations can be made until more personnel and funds can be found.

ARTIFICIAL REVEGETATION

The presence of immense areas of severely deteriorated range lands in the Intermountain Region was early recognized. With time it became generally evident that many extensive areas would not recover in a reasonable period by natural means. This fact, together with the acute need for additional grazing lands, necessitated the development of a sound program of artificial revegetation which was begun 8 years ago. It was clear that unless unproductive ranges were again made to carry a proportionate share of the grazing load many fruitful ranges and watersheds stood in imminent danger of depletion.

Areas requiring artificial revegetation were as numerous and diverse as are the sites in this mountainous and valley region. They varied from dry desert to fairly moist; steep, severely eroded to nearly level lands; badly depleted to rich and productive soils; and from soils highly impregnated with alkaline salts to slightly acid.

When the project in artificial revegetation was launched 8 years ago it was recognized that there were four major distinct classes of range condition for which research in reseeding was needed, as follows: (1) deep, productive soils in valley and foothill zone, precipitation 10 to 20 inches; (2) shallow, unproductive soils and dry sites in valley and foothill zone, precipitation 10 to 20 inches; (3) mountain zone, soils deep to shallow, precipitation generally more than 20 inches, but with short growing season; (4) desert zone, soils deep to shallow, generally unproductive, precipitation usually less than 10 inches. In all not less than 12 million acres of range land needed reseeding and required investigation to provide information for the four range conditions to permit building a reseeding program for each. Since only one class of range could at first be studied thoroughly and since the productive soils on gentle slopes in the valley and foothill zone promised the greatest and quickest return, a research program was organized to study suitable species, time, methods, and costs of reseeding in this zone, with merely exploratory studies in the other three classes.

While not by any means completed, the organized studies in the most favorable class have yielded sufficiently reliable information to permit stating principles and making recommendations for guiding action on the 4 to 5 million acres of abandoned cultivated and depleted range land in this zone. These recommendations for Nevada, Idaho, and Utah have been distributed in Station Research Papers 1, 2, and 3. Cost studies were published in the Journal of Forestry. Several miscellaneous notes on minor technical aspects also have been published.

Some 14 species of which seed is now available on the market and 15 others have proved to be suitable for the good soils of the valleys, foothills, and areas of open aspen. Fall or late summer has for most sites proved the best time for seeding. Seeds need to be covered with soil except in open aspen stands where leaf fall does this in part, though even here covering with soil is an advantage. Seed may be drilled

in Russianthistle stands without previous preparation. Several effective means of removing sagebrush have been partly developed as well as some procedures for seeding in stands of cheatgrass, although most of the problems of revegetating cheatgrass stands are yet to be solved.

This year it is conservatively estimated that approximately 100,000 acres have been seeded in Utah and an additional 60,000 acres in Idaho, Nevada, and Wyoming. Public agencies and private operators are securing profitable results, giving rise to increasing participation. On the favorable sites, it has been demonstrated that where proper procedures are followed grazing gains will offset costs in 7 to 10 years.

The mountainous areas, the desert tracts, the drier sites in the valleys and foothills, especially those occupied by cheatgrass, all present difficult problems, regarding which only suggestive information has as yet been gathered. A systematic program of studies for each class of range is required, not far different from that under way for the most favorable conditions. Different species from those recommended for favorable sites will be required for the high mountains and still others for the desert ranges. Methods and time of planting will likewise need to be modified for the three definitely unfavorable range conditions now in need of a reseeding program.

For 1944 and immediately thereafter the present research will be so reoriented as to begin an organized attack on the unsolved problems of the mountainous forest land. Research will also be directed toward solving the problems of revegetating the cheatgrass and other peculiarly difficult valley and foothill ranges. Removal of thick stands of sagebrush and establishing in their place stands of grass is also an immediately urgent phase of the reseeding problem to be given attention during 1944 and 1945, in cooperation with the spring-fall range project. Continued guidance will be made available to agencies conducting large-scale reseeding operations, particularly for reseeding on national forests.

In addition to this reorientation the following six problems demand investigation. They will receive attention as quickly and vigorously as condition, facilities, and personnel permit. (1) Superior strains of several recommended species will be selected (Bureau of Plant Industry cooperating) and guided into proper channels for the commercial production of seed. (2) Determination of suitable species and methods of seeding ranges, hitherto regarded as of secondary importance because of adversities will be vigorously prosecuted. Among these are pinyon-juniper, saltgrass, greasewood, some desert ranges. (3) Experiments are needed to determine the relative persistence, palatability, and production of major forages in various environments. Information is being sought by administrative agencies as to differential values of species under various degrees of grazing. (4) Refinement of present seeding methods and development of new ones will be energetically continued. Improvement is likely to be effected through cooperation with field agencies carrying out the action programs. (5) The opportunities for improving certain grazing lands that are now clothed with relatively inferior grasses and weeds require

investigation. Necessarily, procedures must be applied that will lessen the competition from the present occupants in order that more productive species may be established. (6) Methods are needed for successfully establishing stands of certain preferred species which are unusually difficult to establish. Certain little-used species, because of their persistence and drought-enduring qualities, might prove highly useful in extremely adverse situations. Treatment of seeds before planting will probably be necessary for some species, such as Indian ricegrass for example.

REVEGETATION OF ABANDONED DRY-FARM LANDS (BENMORE)

In the Intermountain Region are some 4 or 5 million acres of abandoned cultivated land producing much less forage than the land is capable of doing. These lands in comparison with ordinary range land have easily workable and rather productive soils so that considerable gains in forage are likely through revegetation. Since the abandoned lands lie almost entirely in the zone used for spring-fall range, where the greatest feed scarcity exists, low forage production on such a large acreage is serious. Scarcity of forage at the beginning of spring is also more acute than two or three weeks later. The most effective manner of grazing reseeded stands is also unknown. With the hope of learning how to increase forage production and how to manage grazing so as to sustain production, it was decided to undertake an investigation.

Investigations looking toward solutions for these problems were initiated in 1940 on 3,550 acres set aside for research on the Central Utah Land Utilization Project at Benmore, Utah, under a cooperative agreement between the Soil Conservation Service, the Utah Experiment Station, the Bureau of Plant Industry, and the Intermountain Forest and Range Experiment Station. The investigations were divided into three phases: one dealing with establishing a stand; one dealing with grazing of the forage resulting from reseeding; and one dealing with weather conditions and soil preservation.

This project has now advanced to the stage where investigational work has been planned and an outline of the proposed investigations prepared into approximate work plans. Most of the small plots dealing with season and method of reseeding, and aimed to help stockmen in their reseeding efforts, have been sown but require time and care to produce tentative answers to such questions as to how, when, and what to reseed on abandoned lands. The Utah Station and the Intermountain Station will each conduct parts of this reseeding study. Much detailed information regarding reseeding is available from the major project on the reseeding of range lands conducted by the Intermountain Station.

Of the twenty-seven 100-acre pastures to be used in the grazing experiment, reasonably satisfactory stands have been secured in 15 of them by using the best means known at that time. It is believed that usable stands will be obtained in a year or two in the other 12, as seedlings were rather abundant in 1942 and 1943. During the fall of 1942, four

pastures were grazed to remove the forage, and in the fall of 1943 eight pastures were so grazed largely to keep the land cleared of unused dead forage. These preliminary grazing tests indicate the grazing capacity of the pastures to be between 0.6 to 1.2 animal-unit months per acre. The Intermountain Station will lead out in organizing and conducting the study of experimental grazing in the twenty-seven 100-acre pastures to determine what time and intensity of use and what grazing system will give the most satisfactory grazing returns from the forage and from the annuals.

A preliminary soil survey has been made and several rain gages set up at various places on the area. At headquarters a nearly full set of weather data have been recorded since the summer of 1942. Some observations regarding soil erosion, although not much as yet, have been made by the Soil Conservation Service which agency has principal responsibility for this phase.

In future work, data are to be obtained regarding the responses of various forage species to the time and method of seeding. Records will be made of the rate of growth and the volume of forage growth. It is planned also to begin experimental grazing utilization of 12 to 15 pastures. War conditions have, however, so limited personnel and funds available for this purpose that only more general data can be taken. It is planned to conduct the preliminary grazing that is required to start the study, and to take livestock weights and as much vegetation data as possible, adding detailed forage observations and estimates as soon as funds and personnel become available, probably when the present war ends. Meantime observations regarding weather and soil erosion will continue.

The Animal Husbandry Department of the Utah State Experiment Station has planned a controlled breeding experiment with the cattle that will graze the pastures in spring and fall and adjacent areas of Grazing Service lands and of the Wasatch National Forest in summer. Such a study will correlate well with the grazing investigations in the pastures and enhance their value by providing animals more nearly uniform as to age of calves and lactation periods. The effects of breeding control will be compared for the experimental area and for the outside range.

Limited effort during war time will help to put the investigation in condition for detailed studies later on. The gross measurements that can be taken will of themselves be valuable in many respects. When properly staffed this project will permit a rather adequate study of the time of spring grazing, and of two or three systems of grazing at three intensities of use. Grazing capacity and observations on degrees of utilization will come naturally as the study develops.

FOREST (RANGE) ECONOMICS

The work of this division during the past year was devoted largely to the furtherance of various war-food production programs. Some effort also was spent on post-war planning.

Prior to Roth's induction in the Army in June, the station continued giving assistance to State and Department agencies in developing food production goals, with particular reference to range livestock. This effort contributed significantly to the timely marketing of range livestock to meet war demands for meat and fiber. To a highly gratifying degree, this effort also contributed to the forestalling of pressure for increasing the grazing use on public range land. Range abuse has occurred in some localities and especially on some of the privately owned range land where pasture and feed was inadequate to carry the livestock. The overgrazing problem on the national forests, however, appears to be relatively no worse than prior to the war.

Notwithstanding the general success in holding the line against further abuse on the range lands, the outlook is not too promising. Range livestock numbers continue to be held in excess of farm feed and range forage capacity. An adverse climatic year in 1944 would be disastrous. Such an event is not improbable. There is need, therefore, for continuing assistance to Departmental agencies in the guidance of range livestock production and marketing.

Craddock assumed part-time responsibility for the economics work of the station following Roth's induction with a view toward continuing some assistance to the war-food planning programs, but primarily to clarify and develop useful concepts of range-watershed economics. At the request of the Regional Office he prepared a financial control guide and suggestions for developing the region's post-war inventory of watershed management projects. He also assisted in the preliminary phases of the Department's post-war planning report for the State of Utah.

There is need for continuing effort by this division in 1944 on war- and post-war planning, and on a further exploration of the economic aspects of range-watershed management. Detailed technical effort on economic aspects of range management must await Roth's return.

This division will assume a large share of responsibility for developing the preliminary Utah State Agricultural Planning report requested by the Secretary. No doubt some follow-up planning work also required but the magnitude of subsequent work is not yet clear.

The major effort proposed for this division is the preparation of a paper for the Journal of Forestry on watershed economics. There is a need for clarifying concepts and objectives of watershed management and of the physical and economic limitations of this functional aspect of wildland management, especially in the Intermountain Region. The flood control surveys as well as results of influence investigations to date provide ample material for this effort.

FOREST AND RANGE INFLUENCES

Watershed management investigations have been conducted by this station since 1915 for the purpose of seeking solutions to serious flood and water supply problems through treatment of the watershed lands and headwater drainage ways. Flood hazard reduction has been sought through measures which will stabilize the soil and diminish peakflow discharges. Increased usable water supplies have been sought by measures which will either reduce evapo-transpiration losses or shift the timeliness of discharge to conform more closely to periods of water demand.

Efforts of this division in 1943 were devoted to the analyses of accumulated data and to the maintenance of part of the experimental watershed installations.

Croft published a paper in A.G.U. on some recharge phenomena of the heavy soils in the Wasatch Plateau. This paper for the first time shows both time and quantitative relations of water in the snow mantle, in the soil, and in streamflow. Though preliminary, this study provides an initial basis for the analysis and evaluation of the effects of watershed treatment on streamflow.

Most of Croft's time was devoted to a special study of range watershed criteria, discussed elsewhere.

Woodward prepared a paper for A.G.U. on "Infiltration capacities of some plant-soil complexes on Utah range watershed lands." This paper was developed for infiltrometer data obtained in the Sevier Lake Flood Control Survey. It demonstrated the importance of plant cover density and described a method of preparing design curves for average plant densities.

At the Wasatch Branch Station, a streamflow record was maintained on 14 tributaries and sufficient data on precipitation was obtained for their interpretation. At the Great Basin Branch, streamflow records were maintained on five tributaries in addition to the A/B areas. A minimum climatological network was maintained for interpretation of the streamflow records. The maintenance of these records was possible only through financial assistance from the Region. The maintenance of these records, even at minimum level, was of inestimable value because they provide a bases for interpreting and evaluating many years of hydrologic data.

In 1944 it is proposed to continue the experimental watersheds at the Wasatch Branch and the Great Basin Branch Stations on a minimum level as in 1943. It is expected that Croft will spend some time with Ellison in checking the usefulness of the newly defined concepts and criteria for judging condition and trends of range watershed lands. Most of the effort in this division, however, will be devoted to the analysis and publication of accumulated data.

Craddock is reorganizing a paper originally developed by Woodward on the run-off potentials of some Utah range watershed lands. This paper will describe the characteristics of flood-producing summer storms and the

infiltration capacities of some of the common plant-soil complexes. It will also indicate why and to what extent potential flood producing surface run-off can be minimized by increasing the density of the range plant cover. An exposition of these relationships is sorely needed by wildland managers as a basis for understanding watershed management problems.

Craddock also will develop a short paper on the march of soil moisture on deteriorated and reseeded soil profiles. This paper will show the extent to which improvement in the plant cover for soil stability purposes affected soil moisture and recharge requirements over a 2-year period of weekly records.

Croft and Ellison will complete a paper, "Principles and Criteria for Judging High Range Watersheds." The purpose and status of this publication are described elsewhere in this report.

Croft and Thorne will publish a paper, "Some Properties of Wasatch Mountain Soils." Between 1936 and 1940 an inventory of soil and vegetation was made on six north-facing experimental watersheds comprising 780 acres in Farmington Canyon. Results of field observation and laboratory analysis of the samples, it is believed, makes a contribution to the present rather inadequate knowledge of high mountain soil. The paper will present data on geologic normal and accelerated erosion, physical properties, organic matter and moisture relationships, and pH (soil reaction) of soil from a steep north-facing slope covering a 3,000-foot elevational range.

Croft will prepare a short paper on "Observations on the Melting of Snow" for Science. This is to cover such highlights of snow melting and related phenomena as rate and duration of melting, loss by evaporation, air temperature, and vapor pressure, from studies at the Great Basin Branch Station.

Croft will prepare a paper for the Journal of Forestry on "Run-off Characteristics of Some Plant and Soil Types in the High Wasatch Mountains." This paper will present run-off and erosion data from a 176-acre watershed and from 16 plots within its boundaries which are located on the major soil-plant types of the watershed. Run-off from the following plant-soil conditions is presented: bare, eroded soil without plants, terrace-trenched soil, eroded soil with annual plants, eroded soil with depleted shrubs and annual plants, and from normal soil with aspen and herbaceous understory.

Croft also will prepare a paper for A.G.U. on "Some Watershed Recharge and Run-off Phenomena from North-and South-Facing Watersheds in the Wasatch Mountains." This paper will present data showing the broad relationships of precipitation, including accumulation, duration, and melting of snow, soil moisture changes, penetration of free water into the mantle, and streamflow on north- and south-facing watersheds in the northern Wasatch Mountains.

FLOOD CONTROL SURVEYS

Flood control survey work was terminated on June 30. In the last 6 months of this activity, detailed survey reports on the Boise River and Sevier Lake drainage basins were completed and submitted to O.L.U.C. Both reports recommended adoption of programs for the improvement of watershed lands for flood control purposes. We have not been informed as to what action has been taken on these reports in the Secretary's Office.

Both flood control surveys revealed that very unsatisfactory watershed conditions exist on national forest as well as other forest and range lands within the two basins investigated. The revelations concerning the serious condition of the national forests profoundly shocked Administration. The recommendations having a bearing on national forests have been accepted by the Regional Forester and those phases requiring no material capital investment--such as adjustments in grazing use--are being put into effect as rapidly as possible. Estimates of the capital improvements needed are being incorporated in the inventory of watershed management post-war projects.

The flood control activity brought into sharp focus a woeful lack of hydrologic data for evaluating the functional activity of watershed management. Specific data on erosion rates and infiltration capacities which are essential for evaluating sedimentation and peakflow discharge characteristics, were available for only a few of the numerous watershed plant-soil complexes involved. Data regarding the degree and rate that these important functions can be changed are virtually nonexistent. Whereas the Forest Service from its inception has attempted to lead in the technical fields of forest and range management, the equally important field of watershed management has languished. In a very real sense we have forfeited 40 years of fact gathering. Unfortunately, and notwithstanding the alleged importance of watershed management in this region, the need for this type of basic data continues to be largely ignored.

The survey investigations, particularly the run-off and silt load measurements in the Boise and the infiltrometer tests in the Sevier Lake basins, barely scratched the surface of the tremendous field needing attention. An expanded program of influences investigations is urgently needed to obtain the basic data that are required for developing technically sound programs of watershed management.

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STATION PERSONNEL - C. Y. 1943

ADMINISTRATION

Reed W. Bailey	Director
Walter E. Mann	Sr. Adm. Asst.
Marguerite A. Israelson	Sr. Clerk
Leona H. O'Donnell	Clerk
Hazel Ballinger	Sr. Stenographer
Frances Mary Stratford	Jr. Clerk-Stenographer

RANGE INVESTIGATIONS

Grazing Management

George Stewart	Sr. Forest Ecologist
Lincoln Ellison	Range Examiner
Selar S. Hutchings	Assoc. Forest Ecologist
Joseph F. Pechanec	Assoc. Forest Ecologist
Ira Clark	Asst. Conservationist
Earl L. Yersin	Asst. Agricultural Aid
Paul E. Hansen	Jr. Field Assistant

Artificial Reseeding

George Stewart	Sr. Forest Ecologist
C. Kenneth Pearse	Conservationist
Alvin C. Hull, Jr.	Assoc. Forest Ecologist
A. Perry Plummer	Asst. Forest Ecologist
Joseph H. Robertson	Asst. Forest Ecologist
Richard M. Hurd	Jr. Range Examiner

FOREST AND RANGE ECONOMICS

George W. Craddock	Sr. Range Examiner

FOREST AND RANGE INFLUENCES

George W. Craddock	Sr. Range Examiner
A. Russell Croft	Conservationist
Alden Blain	Agricultural Aid

FOREST AND RANGE BIOLOGY

Clarence M. Aldous	Assoc. Biologist
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